

Novel concept for LSS based on advanced microalgal biotechnologies

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Introduction: One of the key issues for successful human space exploration is biomedical life support in hostile space and planetary environments that otherwise cannot sustain life. Bioregenerative life support systems (LSS) are one of the options for atmospheric regeneration. To date, no bioregenerative LSS has shown capability for 100% air regeneration. Nor have these LSS been robust enough to simultaneously provide a regenerable complete food source. In contrast to microalgae, traditional plant approaches, e.g. wheat and lettuce, are lacking essential amino acids, vitamins, and micronutrients. Moreover, the rate of photosynthesis by microalgae significantly exceeds that of high plants.

Nevertheless, the employment of microalgae in LSS technology was restricted, until recently, due to high water demands. Also the per person requirement of a 40L volume of microalgae in a photobioreactor, to provide daily O₂ production, made an algae-based approach less attractive.

Methods: By employing a vertically stacked membrane bioreactor, coupled with a solar tracker and photon-delivery system, a lightweight air revitalization system for space based applications, with minimal water requirements, can be developed. Our preliminary estimations suggest that a membrane bioreactor, 8m³ in volume, comprised of 80m² (twenty 2m x 2m membranes, each spaced 10 cm apart), and a total of 70L of water could produce 2.7 kg of dried microalgal biomass that would supply the energy and essential amino acid requirements, as well as producing sufficient O₂ for the daily needs of a 15 member crew.

Results: Research on the biochemical content of edible blue-green alga *Spirulina* (*Arthrospira*) *platensis* shows a wide spectrum of stable *Spirulina* mutants with an enhanced content of amino acids, β-carotene, and phycobilliprotein *c*-phycocyanin. Feeding animals suffering from radiation-induced lesions, *c*-phycocyanin, extracted from strain 27G, led to a correction in the decrement of dehydrogenase activity and energy-rich phosphate levels, as well as improved antioxidant defense and pyruvate levels, compared to untreated animals. Experimental anemia in rats was corrected by feeding *Spirulina platensis* strains 198B and 27G, (with an enhanced content of methionine, phycobiliproteins and carotenoids). *Spirulina* was recently shown by Ananyev et al, 2005, to be an oxygenic organism with the highest level of photosystem II activity (O₂ production).

Conclusion: We propose therefore to develop a design for membrane-based photoreactors for Lunar and Mars exploration habitat LSS, for the cultivation of genetically modified strains of *Spirulina* to scrub CO₂ and supply astronauts with O₂, protein, vitamins, and immunostimulators.

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